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(54) GRAVITY-DRIVEN FRACTION SEPARATOR AND METHOD THEREOF

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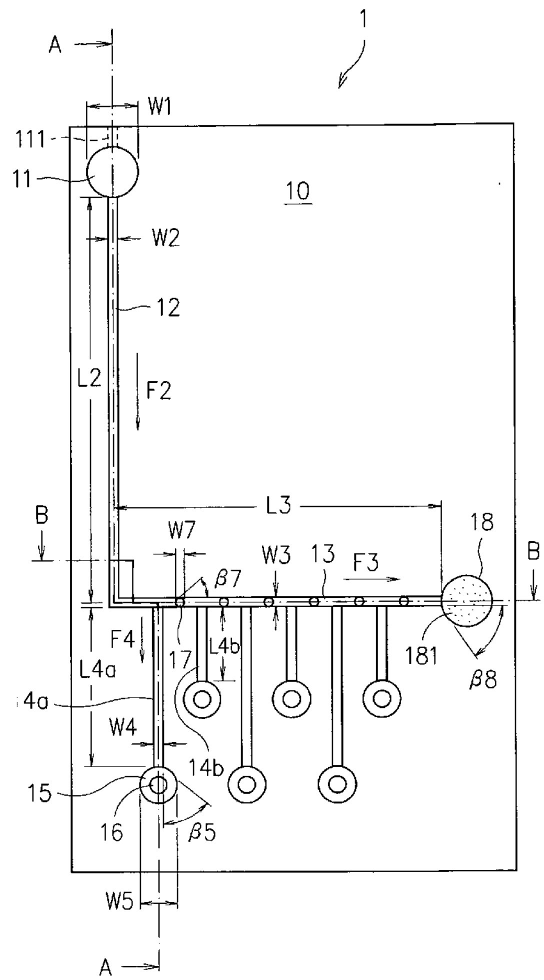
(57) **ABSTRACT**

The present invention relates to a gravity-driven fraction separator and method thereof. The gravity-driven fraction separator is substantially a substrate having a microchannel structure arranged thereon, in which the microchannel structure is extending longitudinally on the substrate while sloping with respect to the level of the substrate by a specific angle. As a micro fluidics is being filled in a loading well situated upstream of the microchannel structure, the micro fluidics is driven by gravity to flow downstream in the microchannel structure while filling a plurality of manifolds formed in a area situated downstream of the microchannel structure, so that accurate quantification and separation of the micro fluidics using the plural manifolds, each having a specific length, can be achieved and provided for posterior inspection and analysis.



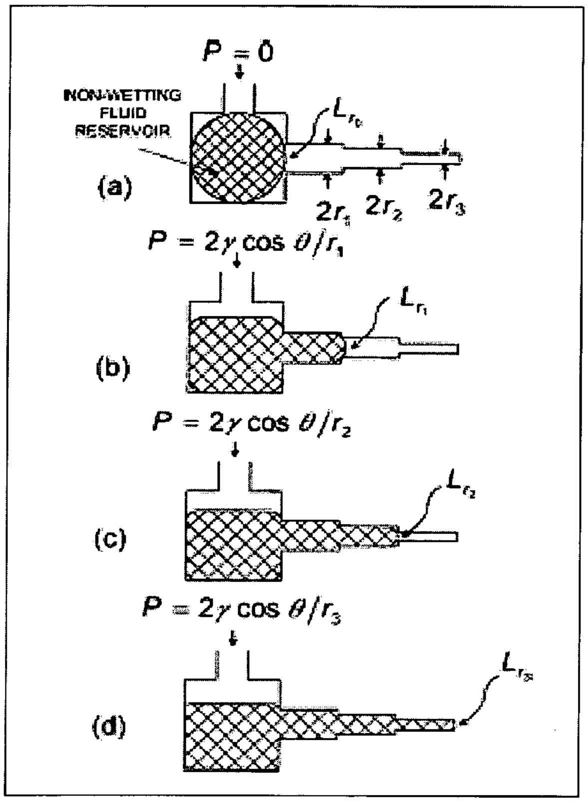


FIG. 1
(PRIOR ART)

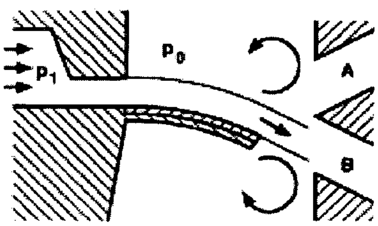


FIG. 2
(PRIOR ART)

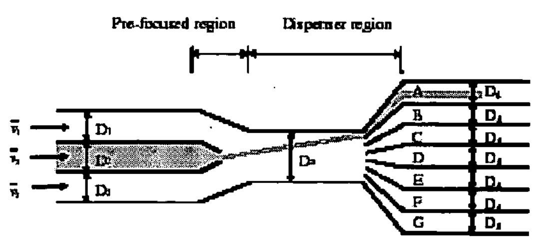


FIG. 3
(PRIOR ART)

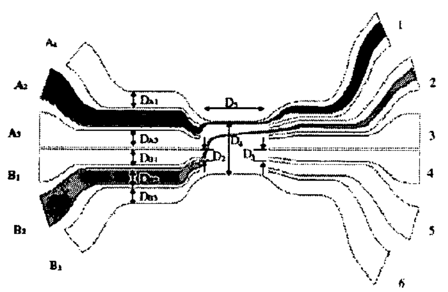


FIG. 4
(PRIOR ART)

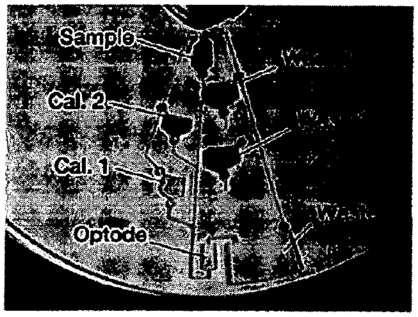


FIG. 5
(PRIOR ART)

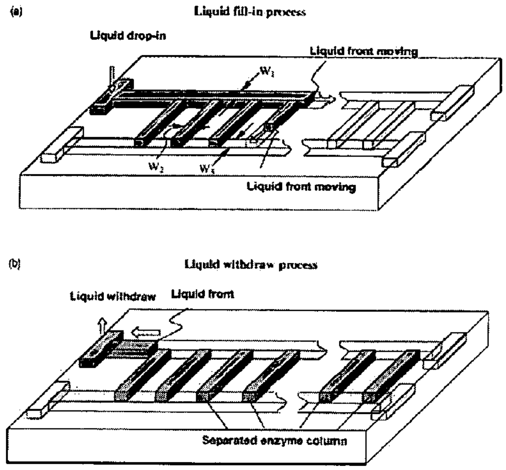


FIG. 6
(PRIOR ART)

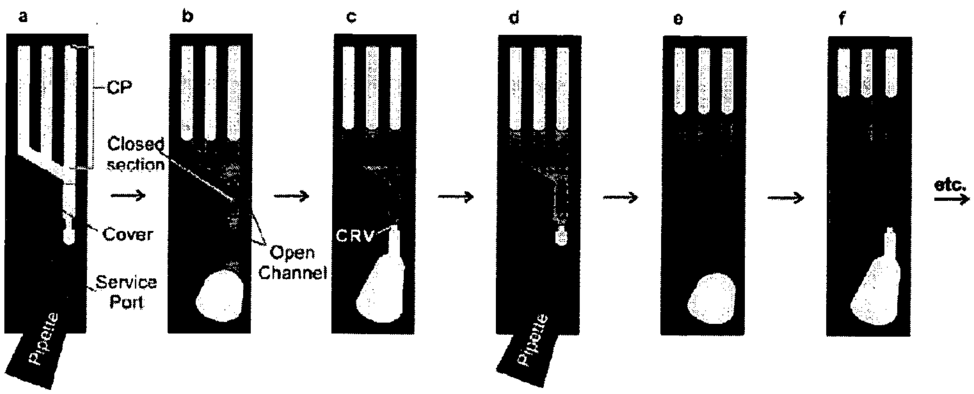


FIG. 7
(PRIOR ART)

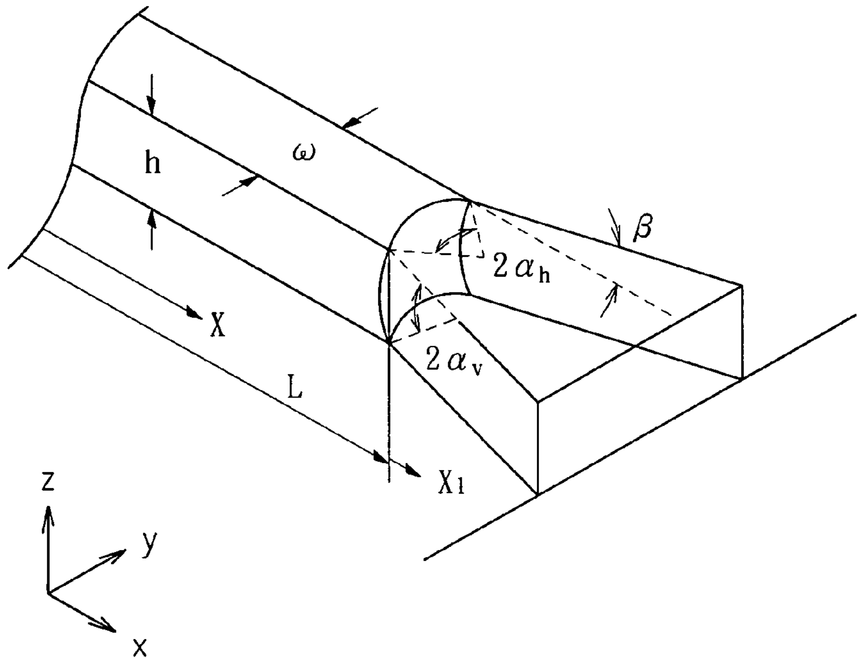

h
ω
β
$2\alpha_h$
$2\alpha_v$
X
L
X_1
z
y
x

FIG. 8

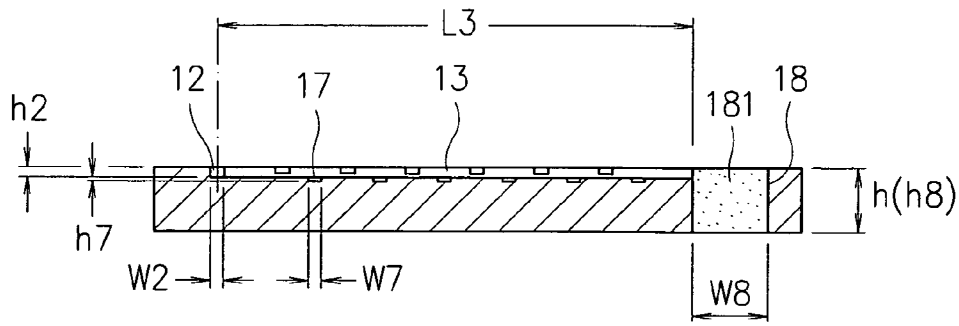

L3
12
17
13
181
18
h2
h7
h(h8)
W2
W7
W8

FIG. 9B

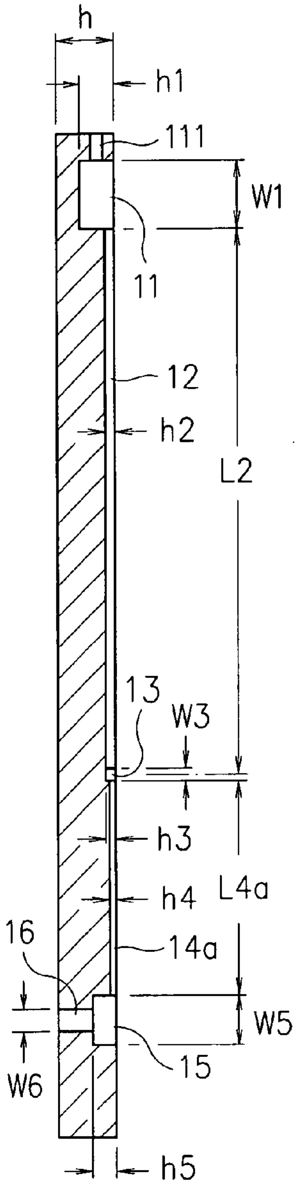

h
h1
111
W1
11
12
h2
L2
13
W3
h3
h4
L4a
16
14a
W5
W6
15
h5

FIG. 9A

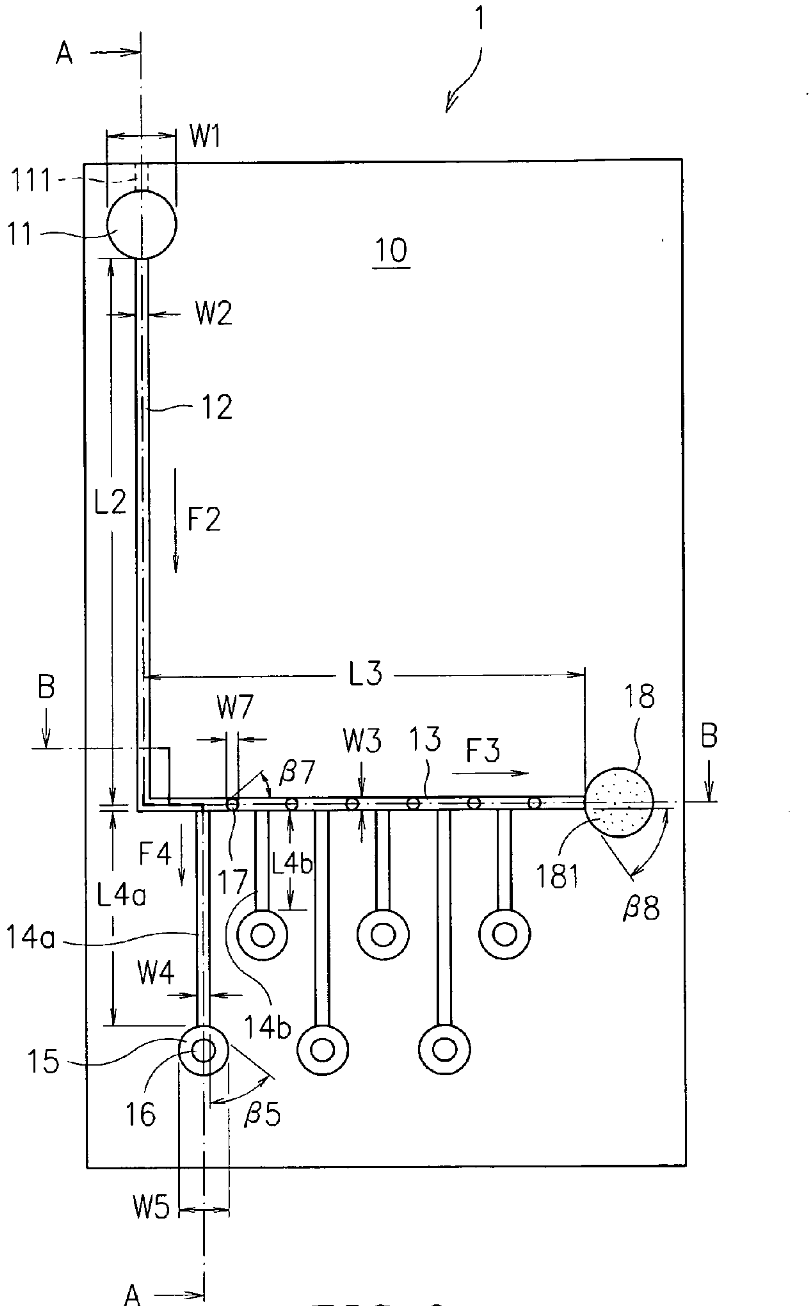

1
A
W1
111
11
10
W2
12
L2
F2
L3
B
W7
β7
W3
13
F3
18
B
F4
L4b
17
181
L4a
β8
14a
W4
14b
15
16
β5
W5
A

FIG. 9

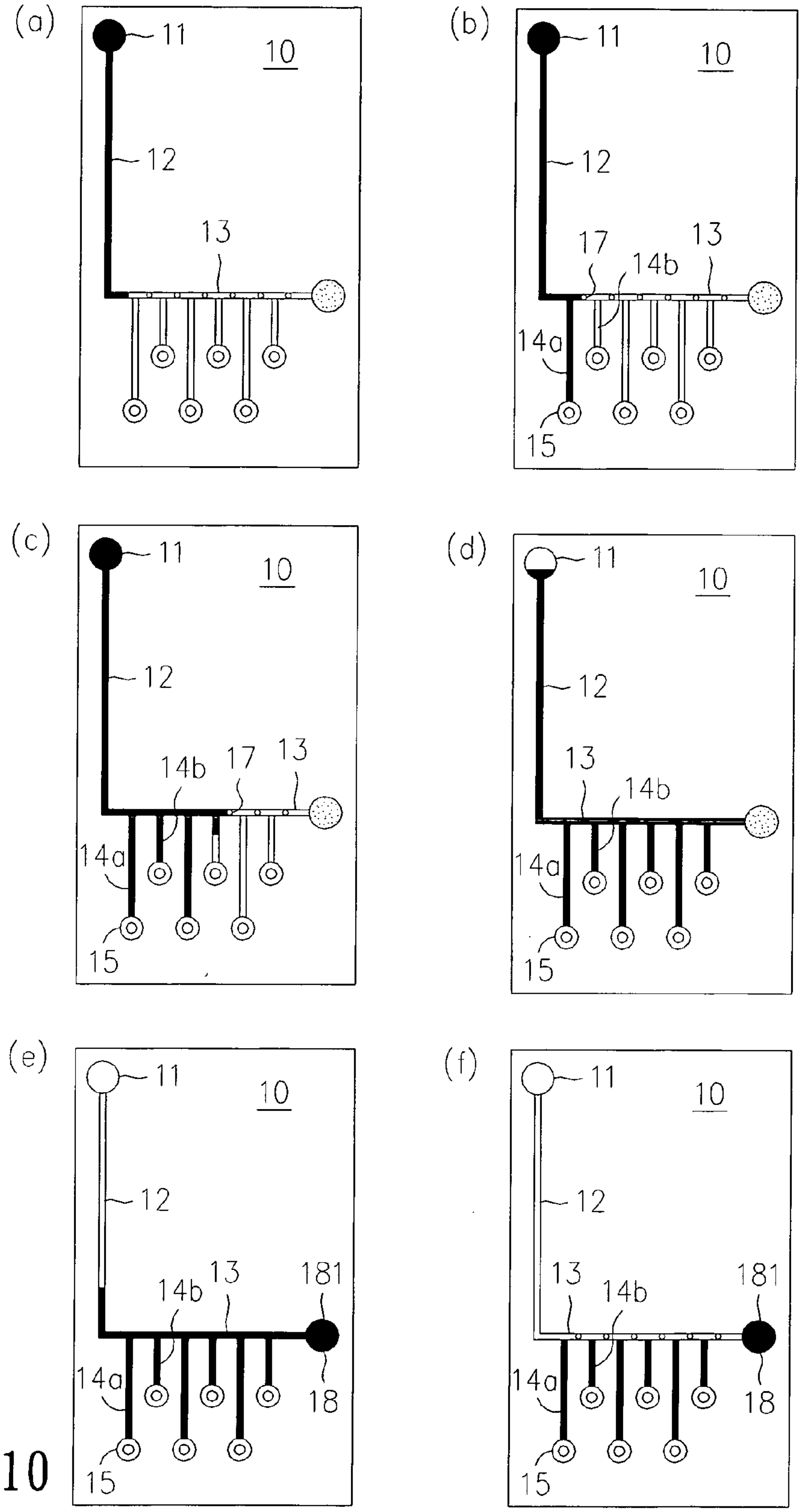

(a)
11
10
12
13
(b)
11
10
12
17
14b
13
14a
15
(c)
11
10
12
14b
17
13
14a
15
(d)
11
10
12
13
14b
14a
15
(e)
11
10
12
14b
13
181
14a
18
15
(f)
11
10
12
13
14b
181
14a
18
15

FIG. 10

GRAVITY-DRIVEN FRACTION SEPARATOR AND METHOD THEREOF

FIELD OF THE INVENTION

[0001] The present invention relates to a gravity-driven separator and method, and more particularly, to a microchannel mechanism without movable valves that is capable of utilizing the geometric structure of the microchannel mechanism for enabling a micro fluidics to be driven to flow by a suction and gravity, and thus an accurate and automatic quantification/separation of the micro fluidics can be achieved. In addition, the process for fabricating the aforesaid separator is relatively simply and can be adapted for all kinds of micro flow system applicable for any micro fluidics operations, such as cell culturing, pharmaceutical inspecting or bio-chemical inspecting, and so on.

BACKGROUND OF THE INVENTION

[0002] As silicon microelectronics have made computation ever faster, cheaper, more accessible and more powerful, the development of microfluidic chips, which are feats of miniscule plumbing where more than a hundred cell cultures or other experiments can take place in a rubbery silicone integrated circuit the size of a quarter, could bring a similar revolution of automation to biological and medical research. Right now biological automation is in its infancy, that it's all about using large robots to push fluids around in the same way that computers in the early days were about big mainframes. It's expensive, bulky, and inflexible. The expense, inefficiency and high maintenance and space requirements of robotic automation systems present barriers to performing experiments. By contrast, microfluidic chips are inexpensive, stable and require little maintenance or space. They also need very small amounts of samples and chemical inputs to make experiments work, making them more efficient, less power consuming, and potentially cheaper to use. However, it is difficult to enable a specimen to be separate into a plurality of samples automatically and accurately for performing various tests thereupon in a microfluidic chip, since the physical attributes of the specimen are not quite the same in the micro world. It is noted that, at the human scale, surface tension is a force of little relevance compared to the force of gravity, however, in a miniaturized scale, the significance of gravity is reduced and the surface tension is a force to reckon with, moreover, not only the cohesion force of the micro fluidics is becoming significant, but also the influence of particle infiltration upon surface in contact with the micro fluidics should not be overlooked any more.

[0003] Hence, it is not a simple task to automate the quantification and separation of a specimen in a microfluidic chip. Please refer to FIG. **1**, which shows the pressures required to be overcome for enabling a micro fluidics to flow through a microchannel of reducing diameters, illustrated in "Utilization of surface tension and wettability in the design and operation of microsensors", Sensors and Actuators B71 (2000) 60-67, by P. G. Wapner, et al. In 2000, Wapner had disclosed that the flowing of a fluid in a microchannel is no longer significantly influenced by gravity, however, other parameters, such as surface tension, are becoming more significant with the decreasing of the diameter of the microchannel. As seen in FIG. **1**, the flow resistance is increase with respect to the decrease of the diameter, so that the design of the microchannel must be changed accordingly.

[0004] Please refer to FIG. **2**, which is a miniaturized microfluidic system disclosed in "Micromachined thermoelectrically driven cantilever structures for fluid jet system", Proc. IEEE Micro Electro Mechanical System Workshop, MEMS'92, 1992, by C. Doring et al. The miniaturized microfluidic system shown in FIG. **2** is characterized in that: the flowing direction of a micro fluidics can be controlled by electrical signals and thus the controlling is facilitated by the operation of certain active devices such as micro valves. However, the aforesaid system is disadvantageous in that the active valves are additional and required for the operation of the microfluidic system.

[0005] Please refer to FIG. **3** and FIG. **4**, which are diagrams illustrating a method for controlling the flowing direction of a micro fluidics, disclosed in J. Micromechanics and Microengineering, 11, 567, 2001 and 11, 654, 2001, by G. B. Lee et al. The aforesaid method is characterized in that the flowing direction of the micro fluidics can be controlled without the help of any valve device. However, the aforesaid method is disadvantageous in that the control of the flowing direction is driven by voltage.

[0006] Please refer to FIG. **5**, which is a biomedical test disc disclosed by Marc J. Madou et al. The biomedical test disc of FIG. **5** is substantially a plastic disc having a plurality of microchannels formed thereon by a means of electroplating and press-molding, whereas the flowing of a micro fluidics is driven by the centrifugal force induced by a rotation platform carrying the test disc with respect to the cooperation of five passive valves fabricated in the microchannels. In addition, microfluidic devices, such as micromixers, are formed on the biomedical test disc. However, the aforesaid biomedical test disc is disadvantageous in that not only the structure of the test disc is complicated, but also additional valves are required for the operation of the biomedical test disc.

[0007] Please refer to FIG. **6**, which is a disposable surface tension driven microfluidic biomedical test chip disclosed by F. G. Tseng et al. The biomedical test chip of FIG. **6** is substantially a substrate having a layer of SU-8 disposed thereon while forming microchannel in the SU-8 layer; wherein the microchannel is formed into a H-shaped structure with a hydrophilic inner wall made of a ploydimethylsilozane (PDMA) material. By the H-shaped microchannel, samples can be dispense to different sensors by the driven of surface tension. However, the aforesaid biomedical test chip is disadvantageous in that it is required to be processed by a plasma process for enabling the microchannel to have a hydrophilic inner wall.

[0008] Please refer to FIG. **7**, which is schematic diagram showing the operation of an autonomous microfluidic capillary system disclosed by B. Michel. The autonomous microfluidic capillary system is adapted to be applied by an immunoassay chip, that it is substantially a formation of a plurality of microchannels of different aspect ratio while integrating the microchannel formation with micro devices, such as micro pump and micro valve, etc., so as to enable a micro fluidics to be separated and flow into each microchannels independent to each other and correspondent to the pressure and resistance exerted thereon by the structure of the corresponding microchannel. However, the aforesaid autonomous microfluidic capillary system is disadvantageous in that the structure of the corresponding immunoassay chip is complicated

[0009] With respect to the abovementioned prior-art disadvantages, the fabrication of microfluidic chip is complicated and costly. Therefore, it is in need of a low-cost, simple-structured and easy-to-implement platform or apparatus that is capable of enforcing an accurate and automatic quantification/separation operation upon a specimen.

SUMMARY OF THE INVENTION

[0010] In view of the disadvantages of prior art, the primary object of the present invention is to provide a gravity-driven fraction separator without movable valves that is capable of utilizing the geometric structure of the microchannel mechanism for enabling a micro fluidics to be driven to flow by a suction caused by gravity, and thus an accurate and automatic quantification/separation of the micro fluidics can be achieved. In addition, the process for fabricating the aforesaid separator is relatively simply and can be adapted for all kinds of micro flow system applicable for any micro fluidics operations, such as cell culturing, pharmaceutical inspecting or biochemical inspecting, and so on.

[0011] To achieve the above object, the present invention provides a gravity-driven fraction separator for accomplishing an accurate and automatic quantification/separation of a micro fluidics, comprising:

[0012] a substrate; and

[0013] a microchannel structure, extending longitudinally on the substrate while sloping with respect to the level of the substrate by a specific angle.

[0014] Preferably, the microchannel structure further comprises:

[0015] at least a main channel, extending while sloping with respect to the level of the substrate by the specific angle; and

[0016] a plurality of manifolds, formed in a area situated downstream of each main channel while each being connected to the main channel corresponding thereto.

[0017] Preferably, the depth of each main channel is different from that of each manifold connecting thereto.

[0018] Preferably, the depth of each main channel is larger than that of each manifold connecting thereto.

[0019] Preferably, at least a pit is formed on each main channel at each interval between any two neighboring manifolds connecting to the main channel.

[0020] Preferably, the plural manifolds are formed parallel to each other.

[0021] Preferably, the lengths of the plural manifolds are different from each other.

[0022] In a preferred aspect, the gravity-driven fraction separator further comprises:

[0023] at least a loading well, each situated upstream of a main channel corresponding thereto, for receiving the micro fluidics and enabling micro fluidics to fill into the corresponding main channel; and

[0024] a plurality of reservoirs, disposed respectively at the ends of the plural manifolds, for receiving the micro fluidics.

[0025] Preferably, the loading well is channel to an opening for enabling a specific pressure to be exerted upon the micro fluidics received in the loading well therethrough.

[0026] Preferably, the cross-section area of each reservoir is different from that of the manifold connecting thereto.

[0027] Preferably, each of the plural reservoirs is channel to a piping capable of generating a suction force.

[0028] Preferably, each main channel further comprises a waste well, situated downstream and at the end of the same.

[0029] Preferably, the cross-section area of each waste well is different from that of the main channel connecting thereto.

[0030] Preferably, an absorbent material is disposed in each waste well.

[0031] Preferably, the absorbent material is a material selected from the group consisting of a super absorbent fiber, other hydrophilic materials and the combination thereof.

[0032] Preferably, each main channel further comprises:

[0033] a first duct, extending longitudinally on the substrate while sloping with respect to the level of the substrate by the specific angle; and

[0034] a second duct, connecting to the first duct while extending transversely with respect to the substrate;

[0035] wherein, the plural manifolds are connected to the second duct while each extending longitudinally on the substrate in a manner similar to that of the first duct.

[0036] Preferably, the diameter of the cross-section area of the microchannel structure is between 0.1 micrometer and 1000 micrometers.

[0037] Preferably, the microchannel structure is formed by milling the substrate.

[0038] Preferably, the interior of the microchannel structure is processed by a hydrophilic/hydrophobic coating.

[0039] Preferably, the substrate is made of Polymethyl Methacrylate (PMMA).

[0040] Preferably, the substrate is sloping wile extending longitudinally with respect to the datum water level for enabling the microchannel structure formed thereon to slope respect to the datum water level by a specific angle while extending longitudinally on the substrate.

[0041] Moreover, to achieve the above object, the present invention provides a gravity-driven fraction method for accomplishing an accurate and automatic quantification/separation of a micro fluidics, comprising steps of:

[0042] (a) filling a micro fluids into the upstream of a microchannel structure, whereas the microchannel structure is extending while sloping with respect to a level by a specific angle;

[0043] (b) enabling the micro fluidics to flow toward the downstream of the microchannel structure as it is driven by gravity; and

[0044] (c) enabling the micro fluidics to fill a plurality of manifolds, whereas each manifold is formed at the downstream of the microchannel structure and each has a specific length.

[0045] Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] FIG. 1 shows the pressures required to be overcome for enabling a micro fluidics to flow through a microchannel of reducing diameters, illustrated in "Utilization of surface tension and wettability in the design and operation of microsensors", Sensors and Actuators B71 (2000) 60-67, by P. G. Wapner, et al.

[0047] FIG. **2** is a miniaturized microfluidic system disclosed in "Micromachined thermoelectrically driven cantilever structures for fluid jet system", Proc. IEEE Micro Electro Mechanical System Workshop, MEMS'92, 1992, by C. Doring et al.

[0048] FIG. **3** is a diagrams illustrating a method for controlling the flowing direction of a micro fluidics, disclosed in "Micromachined pre-focused 1×N flow switches for continuous sample injection", J. Micromechanics and Microengineering, 11, 567, 2001 by G. B. Lee et al.

[0049] FIG. **4** diagrams illustrating a method for controlling the flowing direction of a micro fluidics, disclosed in "Micromachined pre-focused M×N flow switches for continuous sample injection", J. Micromechanics and Microengineering, 11, 654, 2001, by G. B. Lee et al.

[0050] FIG. **5** is a prior-art biomedical test disc disclosed by Marc J. Madou et al.

[0051] FIG. **6** is a prior-art disposable surface tension driven microfluidic biomedical test chip disclosed by F. G. Tseng et al.

[0052] FIG. **7** is schematic diagram showing the operation of a prior-art autonomous microfluidic capillary system disclosed by B. Michel.

[0053] FIG. **8** is a perspective view of a microchannel with micro fluidics flowing therein.

[0054] FIG. **9** is a top view of a gravity-driven fraction separator according to a preferred embodiment of the invention.

[0055] FIG. **9**A is the A-A cross-section of FIG. **9**.

[0056] FIG. **9**B is the B-B cross-section of FIG. **9**.

[0057] FIG. **10** shows continuous steps of a micro fluidics being split and quantified by a gravity-driven fraction separator of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0058] For your esteemed members of reviewing committee to further understand and recognize the fulfilled functions and structural characteristics of the invention, several preferable embodiments cooperating with detailed description are presented as the follows.

[0059] The intension of the present invention is to utilize the physical attributes of a micro-scale micro fluidics for achieving an accurate and automatic quantification/separation of the micro fluidics. In the present invention, gravity is specified as the force used for driving the micro fluidics to flow. As the micro fluidics is driven to flow in a microchannel by gravity, surface tension effect is becoming significant as the change of liquid-gas-solid interface free energy, such that the moving direction of the micro fluidics can be controlled by the structure design of the microchannel or the texture of the microchannel. Hence, as surface tension effect can be adopted for controlling the flowing of a micro fluidics, not additional movable part is required. The theorem of the aforesaid control method is described hereinafter.

[0060] In a microfluidic system as a micro fluidics is flowing in a microchannel, the total interfacial energy U_T of the system is

$$U_T=A_{SL}\gamma_{SL}+A_{SG}\gamma_{SG}+A_{LG}\gamma_{LG} \tag{1}$$

[0061] wherein

[0062] A_{SG} represents solid-liquid interface area;

[0063] A_{SG} represents solid-gas interface area;

[0064] A_{LG} represents liquid-gas interface area;

[0065] γ_{SL} represents solid-liquid surface tension;

[0066] γ_{SG} represents solid-gas surface tension;

[0067] γ_{LG} represents liquid-gas surface tension.

[0068] When a liquid is placed in contact with a solid surface, a contact angle θ_C is formed by the solid/liquid interface and is referred as a liquid-solid contact angle. Hence, the surface tension forces per unit length are related to equilibrium contact angle θ_C by Young's equation, that is,

$$\gamma_{SG}=\gamma_{SL}+\gamma_{LG}\cos\theta_C \tag{2}$$

The effective pressure P applied on the fluid column can be deducted from the derivative of the total interfacial energy U_T of the system with respect to a liquid volume V_L, that is,

[0069]

$$P=\frac{dU_T}{dV_L}=\gamma_{LG}\left(\cos\theta_C\frac{dA_{SL}}{dV_L}-\frac{dA_{LG}}{dV_L}\right) \tag{3}$$

[0070] By the aforesaid formula (3), the pressure driving the micro fluidics is related to the variation of the total interfacial energy U_T and the liquid volume V_L. Thus, it is concluded that a passive valve can be achieved by the control of the total interfacial energy U_T or the liquid volume V_L according to the aforesaid formula (3).

[0071] However, the above description is only fitted to two-dimensional analysis. But in three-dimensional meniscus analysis, meniscus shape is assumed to be two circular arcs of angles, in both horizontal and vertical directions, as shown in FIG. **8**. Therefore, the total interfacial energy U_T becomes

$$U_T=U_0-\gamma_{L\alpha}\cos\theta_C\left[2L(w+h)-\frac{w^2}{2\sin\alpha_h}\left(\frac{\alpha_h}{\sin\alpha_h}-\cos\alpha_h\right)\right]+\gamma_{L\alpha}\frac{wh\alpha_h\alpha_v}{\sin\alpha_h\sin\alpha_v} \tag{4}$$

the liquid volume V_L is

$$V_L=wlh\frac{w^2h}{4\sin\alpha_h}\left(\frac{\alpha_h}{\sin\alpha_h}h-\cos\alpha_h\right)-\frac{wh^2\alpha_h}{4\sin\alpha_v\sin\alpha_h}\left(\frac{\alpha_v}{\sin\alpha_v}-\cos\alpha_v\right) \tag{5}$$

[0072] Thus, it can be seen from formula (4) and formula (5), the design parameter of a passive valve includes:

[0073] (1) microchannel height h;

[0074] (2) microchannel width w; and

[0075] (3) expansion angle β.

[0076] From the above description, a microchannel mechanism without movable valves that is capable of utilizing surface tension effect of the microchannel along with a suction between micro fluidics and gravity can be accomplished, that is, a system capable of achieving an accurate and automatic quantification/separation of the micro fluidics.

[0077] Please refer to FIG. **9**, FIG. **9**A and FIG. **9**B, which are respectively a top view, an A-A cross-sectional view and a B-B cross-sectional view of a gravity-driven fraction separator according to a preferred embodiment of the invention. The gravity-driven fraction separator **1** is substantially a substrate **10** having a microchannel structure arranged thereon, in which the microchannel structure is further comprised of: a main channel composed of a first duct **12** and a second duct **13**; and a plurality of parallelly aligned manifolds **14***a*, **14***b*; wherein, the plural manifolds are connected to the second duct while each extending longitudinally on the substrate in a manner similar to that of the first duct **12**. In a preferred aspect, the substrate **10** is made of Polymethyl Methacrylate (PMMA) of a specific hardness, and the microchannel structure is formed by milling the substrate **10**. In addition, the diameter of the cross-section area of the microchannel structure is between 0.1 micrometer and 1000 micrometers, that is dependent upon the micro fluidics flowing therein.

[0078] The first duct **12** is extending longitudinally on the substrate following an arrow F**2** while sloping with respect to the level of the substrate by the specific angle, that it is substantially a ditch of L**2** length, W**2** width and h**2** depth. Moreover, a loading well **11**, being substantially a circular pit of W**1** diameter and h**1** depth, is arranged at the top of the first duct **12**, through which a great amount of micro fluidics can be injected into the microchannel structure and then driven to flow into the first duct **12**. In a preferred aspect of the invention, the diameter W**1** and the depth h**1** of the loading well **11** are all larger than the width W**2** and the depth h**2** of the first duct **12**. In addition, the loading well **11** is channel to an opening **111** for enabling the atmospheric pressure to exert a specific pressure upon the micro fluidics received in the loading well **11** therethrough so as to force the micro fluidic to flow out of the loading well **111** smoothly.

[0079] The second duct **13** is connecting to the first duct while extending transversely with respect to the substrate **10** following an arrow F**3**, that it is substantially a ditch of L**3** length, W**3** width and h**3** depth; whereas the length L**3** is different from the length L**2** of the first duct **12** while the width W**3** and the depth h**3** are all equal to the width W**2** and the depth h**2** of the first duct **12**. Moreover, an end of the second duct **13** is connected to the base of the first duct **12** while another end of the second duct **13** is connected to a waste well **18**, being substantially a circular pit of W**8** diameter and h**8** depth. In a preferred aspect of the invention, the diameter W**8** and the depth h**8** of the waste well **18** are all larger than the width W**3** and the depth h**3** of the second duct **13**, and an expansion angle β**8** is constructed by the circular shaped waste well **18** and width W**3** of the second duct **13**. In the preferred embodiment shown in FIG. **9**B, the depth h**8** of the waste well **18** is equal to the thickness h of the substrate **10**, that the waste well is a hole piecing through the substrate **10** while having an absorbent material **181** arranged therein. It is noted that the absorbent material **181** can be a material selected from the group consisting of a super absorbent fiber, other hydrophilic materials and the combination thereof. In addition, there is at least a plurality of pits **17** formed on the second duct **13**, each of which is substantially a circular pit of W**7** diameter and h**7** depth. As seen in FIG. **9**B, by the arrangement of the plural pits, the depth of second duct **13** is varying along the flow of the micro fluidics, moreover, an expansion angle β**7** is constructed by the circular shaped pit **17** and width W**3** of the second duct **13**.

[0080] As seen in FIG. **9**, the plural manifolds **14***a*, **14***b* are parallelly aligned to each other and connected to the second duct **13** while each extending longitudinally on the substrate **10** in a manner similar to that of the first duct **11** following an arrow F**4**. In addition, the connecting of the plural manifolds **14***a*, **14***b* is to enable at least a pit **17** to be formed on the second duct **13** at each interval between any two neighboring manifolds **14***a*, **14***b* connecting to the second duct **13**. In the embodiment shown in FIG. **9**, each of the manifold **14***a* is substantially a ditch of L**4***a* length, W**4** width and h**4** depth; whereas the width W**4** is equal to the width W**3** of the second duct **13**, while the depth h**4** is smaller than the depth h**3** of the second duct **13**. The only difference between the manifold **14***a* and the manifold **14***b* is that the length of the manifold **14***b* is shorter than that of the manifold **14***a*. Therefore, for simplicity, only the manifold **14***a* is used for illustration hereinafter. As seen in FIG. **9**, the top of the manifold **14***a* is connected to the second duct **13** while a reservoir **15** is arranged at the base of the manifold **14***a*. The reservoir **15** is substantially a circular pit of W**5** diameter and h**5** depth. In a preferred aspect of the invention, the diameter W**5** and the depth h**5** of the waste well **18** are all larger than the width W**4** and the depth h**4** of the manifold **14***a*, and an expansion angle β**5** is constructed by the circular shaped reservoir **15** and width W**4** of the manifold **14***a*. In addition, each reservoir **15** has a hole **16** arranged therein whereas the hole **16** pieces through the substrate **10** and connected to an external piping for the micro fluidics to exit the microchannel structure therefrom. It is noted that the diameter of the hole **16** can be any size only if it is small than the diameter W**5** of the reservoir **15**.

[0081] As the aforesaid gravity-driven fraction separator **1** is only designed with respect to the three primary parameters, i.e. microchannel height h, microchannel depth h and expansion angle β, it is desire to place the gravity-driven fraction separator **1** in an inclined position of a specific angle for subjecting the micro fluidics flowing therein to be driven by gravity in actual practice. For achieving so, in a preferred embodiment, an addition structure or apparatus is used for lifting the top portion of the substrate **10** so that the substrate **10** is sloping wile extending longitudinally with respect to the datum water level for enabling the microchannel structure, composed of the first duct **12**, the second duct **13** and the plural manifolds **14***a*, **14***b*, to slope respect to the datum water level by a specific angle while extending longitudinally on the substrate **10**, and thus the micro fluidics can be driven to flow by gravity from the first duct **12** toward the plural manifolds **14***a*, **14***b*. It is noted that the additional structure or apparatus can be a support platform or a support arm. Moreover, the substrate **10** can be designed with an inclined surface while forming the microchannel structure on the inclined surface, or the depth of the microchannel structure can be varying along the flowing of the micro fluidic, that both are capable of subjecting the micro fluidic flowing therein to gravity. Other then the above-mentioned, there are various means for subjecting the micro fluidic flowing in the microchannel structure to gravity that are known to those skilled in the art and thus are not described further herein. However, for the plate type substrate **10** shown in FIG. **9**, an adjustable platform or strut is arranged at the bottom of the substrate for achieving the goal of subjecting the micro fluidic flowing in the microchannel structure to gravity.

[0082] From the above description, the micro fluidics is flowing successively passing through the loading well **11**, the first duct **12**, the second duct **13**, the manifolds **14***a*, **14***b* and finally reaching the waste well **18**. As the depth, the width and the expansion angle of the microchannel that the micro fluidics is flowing through are changing along the way, it is intended to illustrate the flowing in the figures (a)~(f) of FIG. **10**. It is noted that the substrate **10** is sloping wile extending longitudinally with respect to the datum water level for enabling the microchannel structure formed thereon to slope respect to the datum water level by a specific angle while extending longitudinally on the substrate **10**, and thus the micro fluidics is driven to flow from the top to the bottom of the substrate **10** while the darkened area of FIG. **10** represents the distribution of the micro fluidics.

[0083] In the figure (a) of FIG. **10**, as soon as a micro fluidics is injected into the loading well **11**, it is driven to flow out of the loading well **11** by the atmospheric pressure of the opening **111** and the gravity and then into the first duct **12** and the second duct successively. Since the width W**3** and the depth h**3** of the second duct **13** are equal to the width W**2** and the depth h**2** of the first duct **12**, the flowing speed of the micro fluidics remain unchanged while flowing through the first and the second ducts **12**, **13**.

[0084] In the figure (b) of FIG. **10**, as the micro fluidics flowing in the second duct **13** reaches the pit **17**, the flow of the micro fluidics is stopped by the resistance caused by the depth h**7** and the expansion angle β**7** of the circular pit **17** that the micro fluidics is forced to flow into the shallower manifold **14***a* of depth h**4** as the micro fluidics is keep flowing out of the loading well **11**. When the manifold **14***a* and the reservoir **15** thereof is filled, by the resistance caused by the diameter W**5** and the depth h**5** of the circular reservoir **15** along with the resulting expansion angle β**5**, the micro fluidics can be stopped from keep flowing into the reservoir **15**.

[0085] In the figure (c) of FIG. **10**, as the resistance of the reservoir **15** is larger than that of the circular pit **17** and the micro fluidics is keep flowing out of the loading well **11**, gravity will overcome the resistance of the pit **17** and force the micro fluidics to keep flowing until it reaches the next pit **17** on the second duct **13** where it is stopped again and redirected to flow into the manifold **14***b*. As the flowing of the micro fluidics is similar to that of the manifold **14***a* only the manifold **14***b* is shorter, the description of the flowing in the manifold **14***b* is not described further herein. Thus, the plural manifolds **14***a*, **14***b* are filled successively, as seen in the figure (d) of FIG. **10**.

[0086] In the figure (d) and figure (e) of FIG. **10**, when all the manifolds **14***a*, **14***b* are filled, as the micro fluidics is keep flowing out of the loading well **11** while the flowing is resisted by the resistance caused by the reservoirs **15** and attracted by the absorbent material **181** disposed in the waste well **18**, the flowing of the micro fluidics is driven to flow toward the waste well **18** until all the micro fluidics filled in the loading well **11**, the first duct **12** and the second duct **13** are all being absorbed by the absorbent material **181**. For those micro fluidics filled the manifolds **14***a*, **14***b*, as the depths h**4** of the manifolds **14***a*, **14***b* are smaller than the depth h**3** of the second duct **13** and the positions of the manifolds **14***a*, **14** b with respect to datum water level is lower than that of the second duct **13**, they will not be drained by the absorbent material **181**.

[0087] In the figure (f) of FIG. **10**, when all the micro fluidics, except for those filled in the manifolds **14***a*, **14***b* are all drained by the absorbent material **181**, each of the plural manifolds **14***a*, **14***b* will accommodate a specific amount of micro fluidics, in that the amount of the micro fluidics can be changed with the changed of the lengths, widths and depths of the plural manifolds **14***a*, **14***b* so as to match the amount of the micro fluidics with the type of the micro fluidics as well as the posterior tests. In the preferred embodiment shown in FIG. **10**, there are three manifolds **14***a* and three manifolds **14***b* so that, for the micro fluidics of two different specific amount, there are three samples in respective. Moreover, each reservoir **15** has a hole **16** arranged therein whereas the hole **16** pieces through the substrate **10** and is connected to an external piping for the micro fluidics to exit the microchannel structure therefrom and into a test tube, collecting bottle, or other devices, to be used for posterior testing.

[0088] Form the abovementioned embodiment, it is concluded that the design of the gravity-driven fraction separator **1** of the invention is able to drive the micro fluidics to flow in the microchannel structure successfully and sufficiently, that is, not only the micro fluidics is driven to flow through those channel of low specific resistance, but also it is enabled to filled the whole microchannel structure completely. Therefore, by the accurate definition of the lengths, widths, depths of the plural manifolds, the goal of accurate and automatic quantification/separation of the micro fluidics can be achieved. The function of the last pit **17**, that is the closest to the waste well **18**, is to provide a resistance to ensure that all the plural manifolds **14***a*, **14***b* are filled by the micro fluidics. Hence, by the absorbing force of the absorbent material **181** disposed in the waste well **18**, the excess micro fluidics remained in the first duct **12** and the second duct **13** can be rapidly drained and collected in the waste well **18**. During the draining of the excess micro fluidics in the first duct **12** and the second duct **13**, by the work of the gravity and the cross-section differences between the manifolds **14***a*, **14***b* and the main channel of the first and the second ducts **12**, **13**, only the micro fluidics remaining in the first duct **12** and the second duct **13** will be absorbed by the absorbent material **181** while the micro fluidics in the manifolds **14***a*, **14***b* will not be affected, and thus the separation and quantification of the micro fluidics are accomplished. Moreover, on order to optimize the flowing of the micro fluidics, the interior of the microchannel structure can be processed by a hydrophilic/hydrophobic coating. After the separation and quantification of the micro fluidics are accomplished, the separated micro fluidics are drained form different holes **16** through independent pipings so as to be used for various tests.

[0089] It is clear that the actual size of the microchannel structure is dependent on the type of the micro fluidics and the required sample amount of the micro fluidics. For the embodiment shown in FIG. **9**, FIG. **9**A and FIG. **9**B, the actual sizes are illustrated in the following table:

	width (diameter)	depth	length
Loading well 11	5.5 mm	3.0 mm	5.5 mm
First duct 12	1.0 mm	1.0 mm	48.0 mm
Second duct 13	1.0 mm	1.0 mm	37.0 mm
Manifold 14a	1.0 mm	0.5 mm	18.0 mm

-continued

	width (diameter)	depth	length
Reservoir 15	3.5 mm	2.0 mm	3.5 mm
Pit 17	1.0 mm	0.3 mm	1.0 mm
Waste well 18	6.0 mm	5.0 mm	6.0 mm

[0090] In addtion, by the gravity-driven fraction separator of the invention, a method capable of achieving an accurate quantification and separation of a micro fluidics can be provided, which comprises steps of:

[0091] (a) filling the micro fluids into the upstream of a microchannel structure, whereas the microchannel structure is extending while sloping with respect to a datum water level by a specific angle;

[0092] (b) enabling the micro fluidics to flow toward the downstream of the microchannel structure as it is driven by gravity; and

[0093] (c) enabling the micro fluidics to fill a plurality of manifolds, whereas each manifold is formed at the downstream of the microchannel structure and each has a specific length.

[0094] To sum up, the present invention is advantageous in that:

[0095] (1) It can successfully split and divide a flow of a micro fluidics into several segments.

[0096] (2) The volume of each segment of the micro fluidics can be accurately defined and specified.

[0097] (3) No movable or active device is required for driving the micro fluidics to flow.

[0098] (4) It is easy to connect with any posterior test.

[0099] While the preferred embodiment of the invention has been set forth for the purpose of disclosure, modifications of the disclosed embodiment of the invention as well as other embodiments thereof may occur to those skilled in the art. Accordingly, the appended claims are intended to cover all embodiments which do not depart from the spirit and scope of the invention.

What is claimed is:

1. A gravity-driven fraction separator for accomplishing an accurate and automatic quantification/separation of a micro fluidics, comprising:

a substrate; and

a microchannel structure, extending longitudinally on the substrate, further comprising:

at least a main channel, extending while sloping with respect to the level of the substrate by the specific angle;

at least a loading well, each situated upstream of the main channel corresponding thereto, for receiving the micro fluidics and enabling micro fluidics to fill into the corresponding main channel;

a plurality of manifolds, formed in a area situated downstream of each main channel while each being connected to the main channel corresponding thereto;

at least a pit, formed on each main channel at each interval between any two neighboring manifolds connecting to the main channel; and

a plurality of reservoirs, disposed respectively at the ends of the plural manifolds, for receiving the micro fluidics.

2. The gravity-driven fraction separator of claim **1**, wherein the depth of each main channel is different from that of each manifold connecting thereto.

3. The gravity-driven fraction separator of claim **1**, wherein the lengths of the plural manifolds are different from each other.

4. The gravity-driven fraction separator of claim **1**, wherein the plural manifolds are formed parallel to each other.

5. The gravity-driven fraction separator of claim **1**, wherein the loading well is channel to an opening for enabling a specific pressure to be exerted upon the micro fluidics received in the loading well therethrough.

6. The gravity-driven fraction separator of claim **1**, wherein the cross-section area of each reservoir is different from that of the manifold connecting thereto.

7. The gravity-driven fraction separator of claim **1**, wherein each of the plural reservoirs is channel to a piping capable of generating a suction force.

8. The gravity-driven fraction separator of claim **1**, wherein each main channel further comprises: a waste well having an absorbent material disposed therein, being situated downstream and at the end of the corresponding main channel.

9. The gravity-driven fraction separator of claim **8**, wherein the cross-section area of each waste well is different from that of the main channel connecting thereto.

10. The gravity-driven fraction separator of claim **8**, wherein the absorbent material is a material selected from the group consisting of a super absorbent fiber, other hydrophilic materials and the combination thereof.

11. The gravity-driven fraction separator of claim **1**, wherein the main channel further comprises:

a first duct, extending longitudinally on the substrate while sloping with respect to the level of the substrate by the specific angle; and

a second duct, connecting to the first duct while extending transversely with respect to the substrate, whereas the plural manifolds are connected to the second duct while each extending longitudinally on the substrate in a manner similar to that of the first duct.

12. The gravity-driven fraction separator of claim **1**, wherein the diameter of the cross-section area of the microchannel structure is between 0.1 micrometer and 1000 micrometers.

13. The gravity-driven fraction separator of claim **1**, wherein the microchannel structure is formed by milling the substrate.

14. The gravity-driven fraction separator of claim **1**, wherein the interior of the microchannel structure is processed by a hydrophilic/hydrophobic coating.

15. The gravity-driven fraction separator of claim **1**, wherein the substrate is made of Polymethyl Methacrylate (PMMA).

16. The gravity-driven fraction separator of claim **1**, wherein the substrate is sloping wile extending longitudinally with respect to the datum water level for enabling the microchannel structure formed thereon to slope respect to the datum water level by a specific angle while extending longitudinally on the substrate.

17. A gravity-driven fraction method for accomplishing an accurate and automatic quantification/separation of a micro fluidics, comprising steps of:

(a) filling a micro fluids into the upstream of a microchannel structure, whereas the microchannel structure is extending while sloping with respect to a level by a specific angle;

(b) enabling the micro fluidics to flow toward the downstream of the microchannel structure as it is driven by gravity; and

(c) enabling the micro fluidics to fill a plurality of manifolds, whereas each manifold is formed at the downstream of the microchannel structure and each has a specific length.

18. The gravity-driven fraction method of claim **17**, wherein the microchannel structure is formed on a substrate and is comprised of:

at least a main channel, extending while sloping with respect to the level of the substrate by the specific angle;

at least a loading well, each situated upstream of the main channel corresponding thereto, for receiving the micro fluidics and enabling micro fluidics to fill into the corresponding main channel;

a plurality of manifolds, formed in a area situated downstream of each main channel while each being connected to the main channel corresponding thereto;

at least a pit, formed on each main channel at each interval between any two neighboring manifolds connecting to the main channel; and

a plurality of reservoirs, disposed respectively at the ends of the plural manifolds, for receiving the micro fluidics.

19. The gravity-driven fraction method of claim **18**, wherein the depth of each main channel is different from that of each manifold connecting thereto.

20. The gravity-driven fraction method of claim **18**, wherein the plural manifolds are formed parallel to each other.

21. The gravity-driven fraction method of claim **18**, wherein the lengths of the plural manifolds are different from each other.

22. The gravity-driven fraction method of claim **18**, wherein the loading well is channel to an opening for enabling a specific pressure to be exerted upon the micro fluidics received in the loading well therethrough.

23. The gravity-driven fraction method of claim **18**, wherein the cross-section area of each reservoir is different from that of the manifold connecting thereto.

24. The gravity-driven fraction method of claim **18**, wherein each of the plural reservoirs is channel to a piping capable of generating a suction force.

25. The gravity-driven fraction method of claim **18**, wherein each main channel further comprises: a waste well having an absorbent material disposed therein, being situated downstream and at the end of the corresponding main channel.

26. The gravity-driven fraction method of claim **25**, wherein the cross-section area of each waste well is different from that of the main channel connecting thereto.

27. The gravity-driven fraction method of claim **25**, wherein the absorbent material is a material selected from the group consisting of a super absorbent fiber, other hydrophilic materials and the combination thereof.

28. The gravity-driven fraction method of claim **18**, wherein the main channel further comprises:

a first duct, extending longitudinally on the substrate while sloping with respect to the level of the substrate by the specific angle; and

a second duct, connecting to the first duct while extending transversely with respect to the substrate, whereas the plural manifolds are connected to the second duct while each extending longitudinally on the substrate in a manner similar to that of the first duct.

29. The gravity-driven fraction method of claim **18**, wherein the diameter of the cross-section area of the microchannel structure is between 0.1 micrometer and 1000 micrometers.

30. The gravity-driven fraction method of claim **18**, wherein the microchannel structure is formed by milling the substrate.

31. The gravity-driven fraction method of claim **18**, wherein the interior of the microchannel structure is processed by a hydrophilic/hydrophobic coating.

32. The gravity-driven fraction method of claim **18**, wherein the substrate is made of Polymethyl Methacrylate (PMMA).

33. The gravity-driven fraction method of claim **18**, wherein the substrate is sloping wile extending longitudinally with respect to the datum water level for enabling the microchannel structure formed thereon to slope respect to the datum water level by a specific angle while extending longitudinally on the substrate.

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